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Chemical and Organoleptic Properties of Dragon Fruit Gummy Candy and Apple Snail Collagen Extract with Carrageenan Addition

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A B S T R A C T

Gummy candy is a soft confectionery crafted from fruit juice, sugar, and gelling agents, known for its chewy texture. The utilization of dragon fruit juice enhances its nutritional value due to its antioxidant properties, phenolic compounds, and vitamin C content. Additionally, it aims to diversify products derived from dragon fruit. Meanwhile, the utilization of collagen from apple snails seeks to boost the economic value of these snails and provide an alternative source of collagen raw material. In this study, the gummy candy uses carrageenan as a hydrocolloid material to establish the chewy texture. This study's primary objective is to determine the optimal combination involving the proportion of dragon fruit juice, apple snail collagen extract, and carrageenan concentration for producing high-quality gummy candy. The research employed a Completely Randomized Design (CRD) with a two-factor factorial pattern and two replications. The first factor was the proportion of dragon fruit juice to apple snail collagen (70:30, 75:25, and 80:20), while the second factor was the carrageenan concentration (3%, 5%, and 7% w/w). Observational data were analyzed using Analysis of Variance (ANOVA), and if interactions were observed, they were further assessed with Tukey's test at a significance level of 5%. The treatment combination of a 75:25 proportion of dragon fruit juice to apple snail collagen and a 7% carrageenan concentration proved to be the most effective, yielding gummy candy with a moisture content of 13.21%, ash content of 0.95%, and organoleptic evaluation scores for aroma, taste, color, and texture of 3.25, 3.4, 3.4, and 3.7.

1. INTRODUCTION

1.1. Research Background

Gummy candy is a processed food product that is widely loved by people of all ages, from adults to children, due to its sweet taste, attractive shape, and the convenience of consuming it at any time. Therefore, it has become one of the preferred choices for modern society as a practical and healthy snack to meet their nutritional needs. Gummy candy, also known as soft candy, is a solid snack made from sugar, water, flavorings, and gelling agents [1]. Most gummy candies available in the market are made by adding chemical-based essences. To address this, there is a need for formulations that use fruit juices, such as dragon fruit, to produce gummy candy [2]. Dragon fruit is rich in beneficial substances for the body, such as antioxidants (phenols, flavonoids, vitamin C, and betacyanins), vitamin B3 (niacin), and fiber [3].

Collagen is one of the compounds in food and beverages that is currently in high demand among consumers. The collagen market was valued at over USD 4 billion in 2022 and is predicted to grow by more than 8% from 2023 to 2032 [4]. Collagen is used in the food and beverage industry to enhance product quality and nutritional value [5]. It finds widespread use in the food industry, including beverages, and is also an ingredient in cosmetics [6]. Consuming collagen has been shown to significantly improve skin moisture, elasticity, firmness, skin density, and brightness after use [7].

Most commercially available collagen is derived from sources such as cattle and pigs, which may not align with the

religious beliefs of some communities. The use of pig-derived collagen is a concern for Islamic communities, while cattle-derived collagen raises concerns among Hindu communities and has the potential risk of transmitting Bovine Spongiform Encephalopathy (BSE) [8]. Therefore, there is a need for alternative sources of collagen, such as apple snails, to be acceptable to all segments of the population. Apple snails have good nutritional value because they contain relatively high protein content compared to other types of snails. Currently, collagen extraction from apple snails (*Pila ampullacea*) remains largely unexplored, making it necessary to innovate in the processing of apple snails to provide a solution for pest management and an effective way to extend their shelf life while increasing their economic value.

One of the factors that influence the quality of gummy candy is the use of gelling agents to create a strong gel and a chewy texture. One such gelling agent that can be used in gummy candy production is carrageenan [9].

Based on the above explanation, this research is conducted to determine the proportion of dragon fruit juice and apple snail collagen, as well as the addition of carrageenan concentration, to formulate an optimal gummy candy that exhibits favorable physicochemical and organoleptic characteristics and is well-received by consumers.

1.2. Literature Review

Gummy candy is a confectionery product made from fruit juice or fruit extract and gelling agents, resulting in a texture characterized by its elasticity. There is a wide variety of flavors and shapes of gummy candies available in the market today [10]. Generally, gummy candies have a soft texture that is easy to cut, yet firm enough to maintain their shape. They are non-sticky, non-slimy, and do not break easily, making them a desirable confectionery product with a smooth and gentle texture [11].

Dragon fruit contains bioactive compounds that are beneficial for the body, including antioxidants (ascorbic acid, beta-carotene, and anthocyanins). Additionally, dragon fruit contains various minerals such as calcium, iron, and others. Vitamins found in dragon fruit include vitamin B1, vitamin B2, vitamin B3, and vitamin C [12]. Consuming dragon fruit offers several health benefits, including antioxidants to prevent free radical damage that can lead to cancer and other health issues, controlling blood sugar levels, especially in type 2 diabetes patients, lowering blood pressure, improving digestion, promoting weight loss, detoxifying the body, and supporting eye health [13].

Apple snails (*Pila ampullacea*) belong to the gastropod class and fall under the ampullariidae family. They can be found in Southeast Asia, including the Philippines, Singapore, Kalimantan, Sumatra, Java, and other regions [14]. These snails are commonly found in rice fields, ditches or irrigation channels, lake ponds, and wetlands with freshwater, including mangrove swamps in significant numbers [15]. Apple snails are considered pests because they feed on rice plants, leading to crop damage. They have distinguishing characteristics, including a brown shell and creamy white to reddish flesh in mature individuals [16].

Collagen is a part of the extracellular matrix protein that plays a crucial role in maintaining the structure of various tissues. It is a major component of connective tissues such as skin, bones, tendons, blood vessels, basement membranes, cartilage, and teeth, constituting about one-third of the total animal protein content [17]. Collagen protein has a varied composition of amino acids, primarily proline and hydroxyproline. Glycine, proline, and hydroxyproline are the most important amino acids in collagen, contributing to 50% of its total protein content [18].

The addition of a high concentration of carrageenan results in a firmer texture of gummy candy. Carrageenan possesses stronger gelling capabilities than gelatin. Carrageenan forms water-soluble gels, making it easier to dissolve during the gummy candy manufacturing process [19]. The gel formation process in carrageenan begins with the polymerization of carrageenan into random coil structures. This transformation is induced by heating at temperatures higher than the carrageenan gelation temperature. When the temperature is lowered, carrageenan polymers form double helix structures and create junction points in the polymer chains. The formation of carrageenan gel is influenced by factors such as the quantity and type of ions that affect gel formation. The presence of ions in carrageenan specifically binds to the helical structure of carrageenan gel and facilitates helix formation [20]

1.3. Research Objective

The study aims to determine the chemical and organoleptic characteristics of gummy candy

2. MATERIALS AND METHODS

2.1. Materials and Tools

The raw materials used in this study were dragon fruits from Pahing Rungkut traditional market, apple snail (*Pila ampullacea)* from *Fresh Seafood* Surabaya, and carrageenan with the brand Sobat Keto. Other additional ingredients include sucrose, glucose syrup, citric acid, and castor.

The equipment that is used in this study are Memmert® Oven U055, Muffle Furnace 1.3 L 1100C, water bath, hot plate, thermometer, Miyako blender, filter paper, Erlenmeyer, and stirrer.

2.2. Design of Experiment and Analysis

This research was designed by Completely Randomized Design (CRD) with two factorials. Factor I was the dragon fruit juice : apple snail collagen concentration (70:30, 75:25, dan 80:20), while factor II was carrageenan concentration (3%, 5%, dan 7% b/b).

Table 1. Treatment combinations of gummy candy

Factor I	Factor II		
	B_1	B_2	B_3
A_1	A_1B_1	A_1B_2	A_1B_3
A_2	A_2B_1	A_2B_2	A_2B_3
A_3	A_3B_1	A_3B_2	A_3B_3

Wherein,

A1B1 = Proportion of dragon fruit juice and apple snail collagen (70% : 30%) the concentration of carrageenan 3%
A1B2 = Proportion of dragon fruit juice and apple snail collagen (70% : 30%) the concentration of carrageenan 5%
A1B3 = Proportion of dragon fruit juice and apple snail collagen (70% : 30%) the concentration of carrageenan 7%

A2B1 = Proportion of dragon fruit juice and apple snail collagen (75% : 25%) the concentration of carrageenan 3%
A2B2 = Proportion of dragon fruit juice and apple snail collagen (75% : 25%) the concentration of carrageenan 5%
A2B3 = Proportion of dragon fruit juice and apple snail collagen (75% : 25%) the concentration of carrageenan 7%
A3B1 = Proportion of dragon fruit juice and apple snail collagen (80% : 20%) the concentration of carrageenan 3%
A3B2 = Proportion of dragon fruit juice and apple snail collagen (80% : 20%) the concentration of carrageenan 5%
A3B3 = Proportion of dragon fruit juice and apple snail collagen (80% : 20%) the concentration of carrageenan 7%

The product observation data were analyzed using ANOVA and followed by Tukey at a 5% significance level. Obtained observational data were then tabled and plotted in the form of a regression curve so that a linear regression would be obtained using the Microsoft Excel 2019 program. Research Procedure

2.3. Research Produce

The process of making candy in this study is based on a modification of the previous research method [21] by mixing all the ingredients according to the temperature treatment of 80°C for ± 4 minutes and mold, then let stand at room temperature for 1 minute. Then the candy is cooled in the refrigerator for 24 hours, after which it is coated with castor sugar.

2.4. Observations

2.4.1. Gummy Candy Chemical Observations
Analysis parameters include moisture content (%) & and ash content using gravimetric methods.

2.4.2. Gummy Candy Sensory Observations Sensory
Sensory attributes selected to assess the quality of candy are aroma, taste, color, taste and texture. There were 20 panelists rating the acceptability of the product on a scale of 5 points, ranging from "most liked" to "most disliked". Data analysis involved the Friedman test.

3. RESULT AND DISCUSSION

3.1. Chemical Analysis

3.1.1. Moisture content (%)

The moisture content of gummy candy is shown in Table 2. The moisture content in gummy candy ranges from 12.43% to 16.24%. Variance analysis reveals a significant interaction between the proportion of dragon fruit juice and apple snail collagen and the concentration of carrageenan concerning the moisture content of gummy candy ($P \leq 0.05$). The treatment with a proportion of dragon fruit juice and apple snail collagen (80:20) and the addition of 3% carrageenan resulted in the highest moisture content, which was 16.24%. Conversely, the treatment with a proportion of dragon fruit juice and apple snail collagen (70:30) and the addition of 7% carrageenan yielded the lowest moisture content at 12.43%. The moisture content in the gummy candy complies with the Indonesian National Standard 3547-2-2008, which stipulates a maximum moisture content of 20%.

As the proportion of dragon fruit juice increases, the proportion of apple snail collagen decreases, and the concentration of carrageenan decreases; the moisture content of the gummy candy produced increases. This phenomenon is attributed to the high moisture content of dragon fruit and the water-binding capacity of collagen, resulting in lower moisture content in the gummy candy. Dragon fruit has a high moisture content, approximately 90.2% [22]. The properties of collagen related to gel behavior, such as gel formation, texture enhancement, thickening, and water-binding capacity [23], also contribute to this effect.

Higher carrageenan concentrations can reduce the moisture content of gummy candy because carrageenan functions as a thickening agent with the ability to bind water. This aligns with previous research [24], which states that carrageenan acts as a thickening agent with water-binding capabilities. The addition of carrageenan to food products can increase the viscosity of the material and reduce moisture content [25]. As the carrageenan concentration added to food products increases, the solid content also increases, leading to a reduction in the material's moisture content. This is consistent with another study [26], which suggests that ginger gummy candy production experiences a decrease in moisture content with an increase in carrageenan concentration due to the higher amount of solids. Higher carrageenan concentrations reduce the amount of free water in the material, resulting in a stronger gel structure. Carrageenan is known for its water-binding properties due to its negatively charged sulfate groups along its polymer chain, causing a decrease in the number of free water molecules [27]. In the production of gummy candy, carrageenan binds water and is referred to as bound water. The higher the amount of added carrageenan, the more bound water is present.

3.1.2. Ash content (%)

The ash content of gummy candy is shown in Table 2. The ash content in gummy candy varies from 0.57% to 1.05%. Variance analysis reveals a significant interaction between the proportion of dragon fruit juice and apple snail collagen and the concentration of carrageenan concerning the ash content of gummy candy ($P \leq 0.05$). The treatment with a proportion of dragon fruit juice and apple snail collagen (80:20) and the addition of 7% carrageenan resulted in the highest ash content, which was 1.05%. Conversely, the treatment with a proportion of dragon fruit juice and apple snail collagen (70:30) and the addition of 3% carrageenan yielded the lowest ash content at 0.57%. The ash content in the gummy candy complies with the Indonesian National Standard 3547-2-2008, which specifies a maximum ash content of 3%.

As the proportion of dragon fruit juice increases, the proportion of apple snail collagen decreases, and the concentration of carrageenan increases; the ash content of the gummy candy produced also increases. This is attributed to the mineral content present in dragon fruit. This aligns with previous research [28], which indicates that dragon fruit contains minerals such as calcium, phosphorus, and iron, which are beneficial for enhancing the body's immune system. Foods with high mineral content tend to have higher ash content [29]. The addition of collagen can reduce the ash content because collagen has minimal or no mineral content due to the extraction process using NaOH, which dissolves non-collagenous components. The use of NaOH solution aims to remove non-collagenous components, including non-collagen proteins (enzymes and fibrinogen), fats, minerals, pigments, and odors. The NaOH solution can cause the meat to

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expand, facilitating the dissolution of non-collagenous components [30].

The addition of carrageenan concentration can similarly increase the ash content because it is a compound containing minerals. This is supported by [31], which states that the higher the concentration of added carrageenan, the higher the ash content of gummy candy, as carrageenan is derived from seaweed, which is a food material with relatively high mineral content. Carrageenan can create a three-dimensional mesh that binds the mineral content in the product, thereby preserving the minerals it contains [32]. Increasing levels of carrageenan can bind more minerals from fruits, water, and dissolved solids, consequently increasing the ash content [33]. The mineral content in carrageenan reaches 10.47%, comprising Mg, Ca, and K [34].

Table 2. Chemical analysis of gummy candy

Treatments	Chemical analysis	
	Moisture content (%)	Ash content (%)
A_1 B_1	14.48 ± 0.396	0.57 ± 0.021
A_1 B_2	13.76 ± 0.156	0.66 ± 0.028
A_1 B_3	12.43 ± 0.156	0.86 ± 0.034
A_2 B_1	15.23 ± 0.290	0.68 ± 0.028
A_2 B_2	13.76 ± 0.064	0.83 ± 0.042
A_2 B_3	13.21 ± 0.141	0.95 ± 0.031
A_3 B_1	16.24 ± 0.191	0.68 ± 0.014
A_3 B_2	14.62 ± 0.219	0.75 ± 0.035
A_3 B_3	13.38 ± 0.255	1.05 ± 0.034

3.2. Sensory Analysis

3.2.1. Aroma

Based on Table 3, the highest aroma score is 3.25. This is because the distinctive aroma of dragon fruit that appears to cover up the aroma of the fishy-smelling apple snail collagen. The aroma of dragon fruit is not overly dominating but still received by the panelists' sense of smell due to the slightly added aroma of hydrocolloid material with concentration. This is in accordance with the statement [35] which states that increasing the concentration of hydrocolloid ingredients in food formulations will increase the thickness of the related product, but increasing the concentration of these hydrocolloid ingredients actually reduces the original taste and aroma of the product. Dragon fruit has a distinctive aroma that is fruity and sweet. Methyl hexanoate is a volatile component that gives a fruity, fresh, sweet aroma [36]

3.2.2. Taste

Based on Table 3 the highest taste score is 3.7. This is because the sweet taste comes from dragon fruit according to the panelists. This is in accordance with [37] which states that dragon fruit has very sweet fruit flesh. The addition of carrageenan can also affect the sweet taste of gummy candy. According to research by [38] which stated that at high levels of carrageenan tend to produce a sturdy gel. The high gelation effect is thought to mask the taste of the gummy candy. the addition of carrageenan with higher concentrations can provide a stronger sweet taste [39].

3.2.3. Color

Based on Table 3. the highest color score is 3.75. This is because the color of the candy produced generally has the same color, namely purplish red which comes from the color of dragon fruit. This is the same as [40] which stated that the bright purplish-red dragon fruit contains betacyanin pigment which can act as an antioxidant. Apple snail collagen produces a yellowish white color. The carrageenan used is also colorless. Carrageenan has no color pigment, carrageenan before it is dissolved is brownish white and after it is dissolved in hot water so that the carrageenan dissolves and forms a transparent gel [41].

3.2.4. Texture

Based on Table 3. the highest texture score is 3,7. This is because the texture of the gummy candy is affected by the addition of collagen and carrageenan. The properties of collagen are related to gel behavior, namely gel formation, providing texture, thickening, and water binding capacity. So Collagen acts as a thickening agent which can increase the gel strength of the gummy candy [23]. The more carrageenan added tends to give a stronger texture because carrageenan is a hydrocolloid that functions to form a gel. This is in accordance with [39] that a high concentration of carrageenan produces a strong gummy candy texture.

Table 3. Sensory analysis of gummy candy.

Treatments	Sensory attributes			
	Aroma	Taste	Color	Texture
$A_1 B_1$	2.45	2.55	3.3	2.8
$A_1 B_2$	2.95	2.85	3.25	2.95
$A_1 B_3$	2.9	3	3.5	2.4
$A_2 B_1$	2.9	3.25	3.65	3.05
$A_2 B_2$	2.85	3.7	3.75	3.45
$A_2 B_3$	3.25	3.4	3.4	3.7
$A_3 B_1$	2.95	3.4	3.7	3.65
$A_3 B_2$	3.4	3.3	3.35	3.3
$A_3 B_3$	3.2	3.2	3.6	3

4. CONCLUSION

There is a significant interaction in the treatment of the dragon fruit juice, apple snail collagen, and carrageenan concentration on moisture content, ash content, and organoleptic aroma, taste, and texture. There was no significant influence on the product's color. The best treatment was the formulation of dragon fruit juice : apple snail collagen with a ratio of 75:25 and a 7% concentration addition of carrageenan, resulting in a gummy candy with moisture content of 13.21%, ash content of 0.95%, and organoleptic evaluation scores for aroma, taste, color, and texture of 3.25, 3.4, 3.4, and 3.7.

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